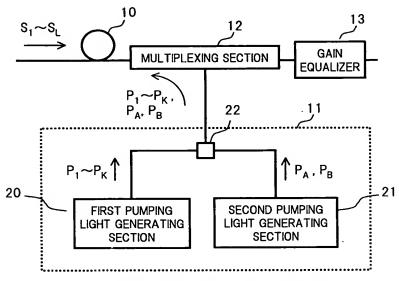
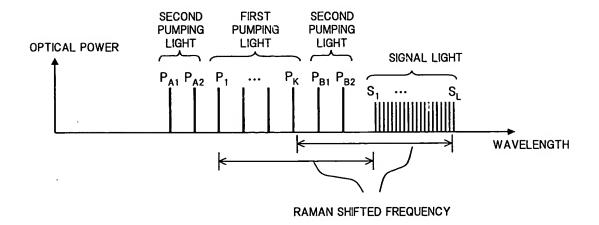
FIG.1

#### RAMAN AMPLIFIER OF FIRST EMBODIMENT OF PRESENT INVENTION



MULTI-WAVELENGTHS PUMPING LIGHT SOURCE

# FIG.2



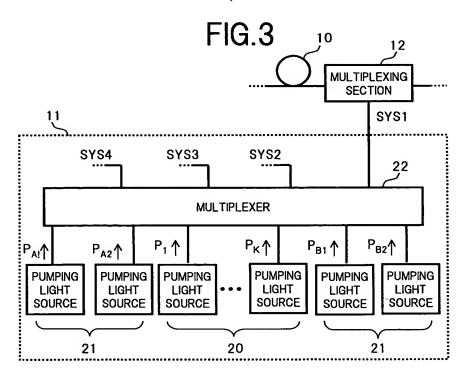


FIG.4

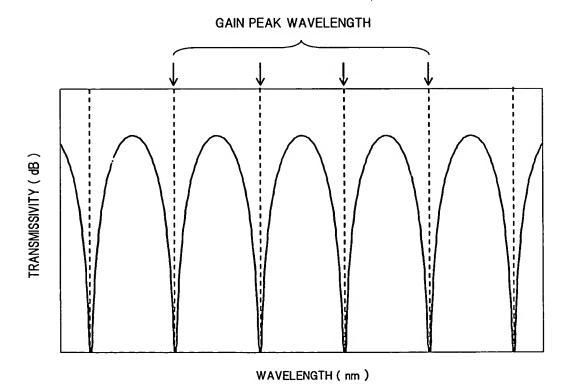


FIG.5



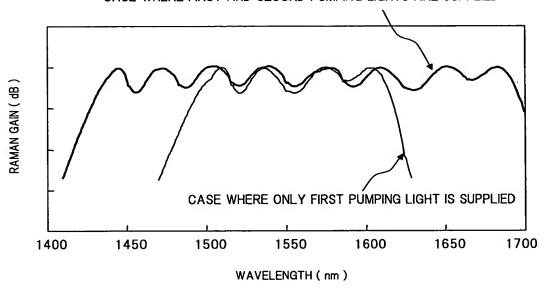


FIG.6

#### RAMAN AMPLIFIER OF SECOND EMBODIMENT OF PRESENT INVENTION

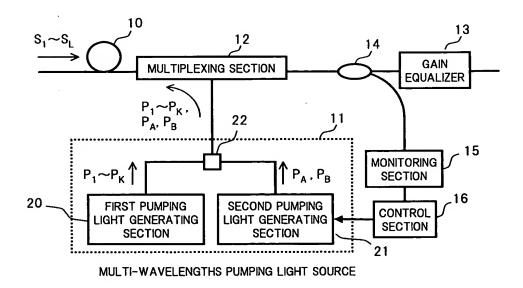


FIG.7

### RAMAN AMPLIFIER OF THIRD EMBODIMENT OF PRESENT INVENTION

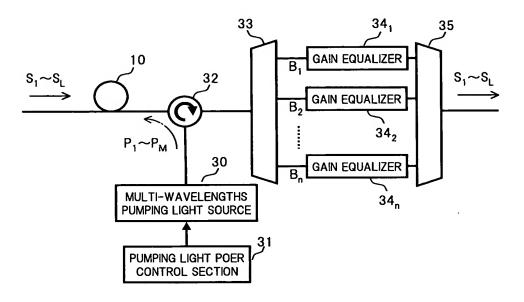


FIG.8

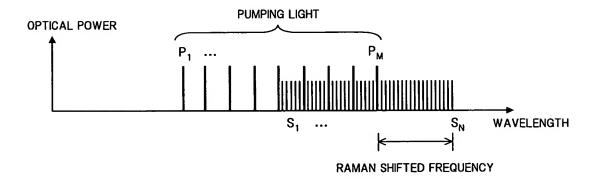
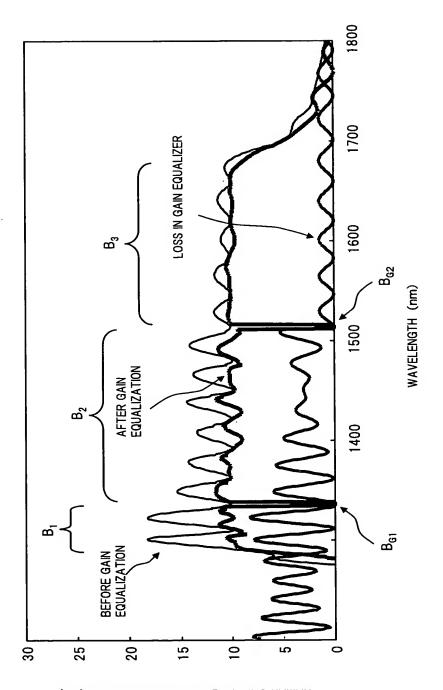


FIG.9



RAMAN GAIN OR LOSS IN GAI EQUALIZER (4B)

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**FIG.10** 

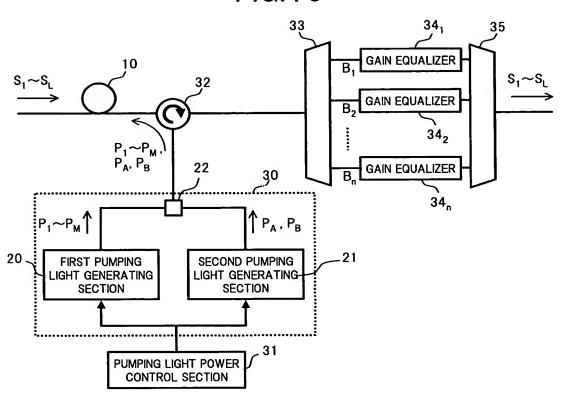
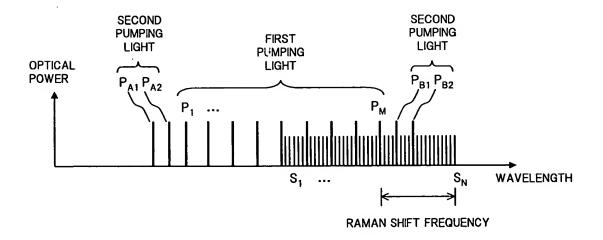


FIG.11



### RAMAN AMPLIFIER OF FOURTH EMBODIMENT OF PRESENT INVENTION

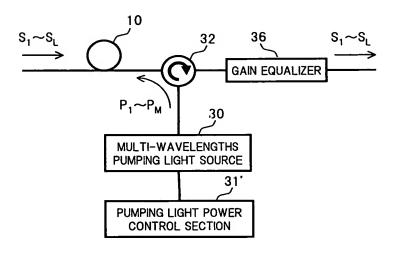


FIG.13

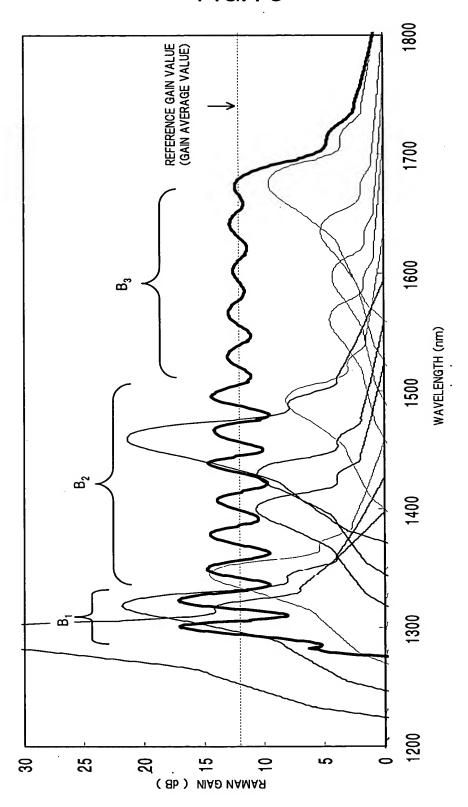


FIG.14

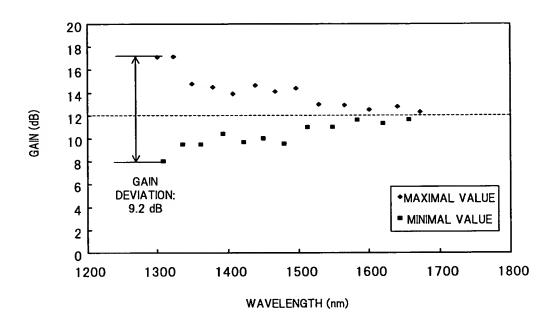
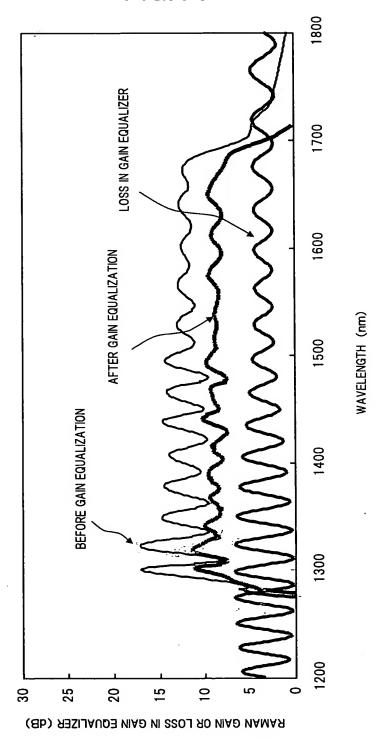


FIG.15



**FIG.16** 

### RAMAN AMPLIFIER OF FIFTH EMBODIMENT OF PRESENT INVENTION

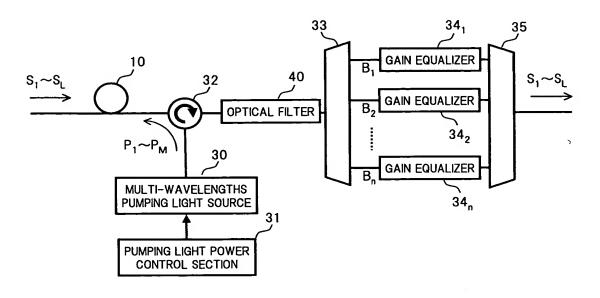
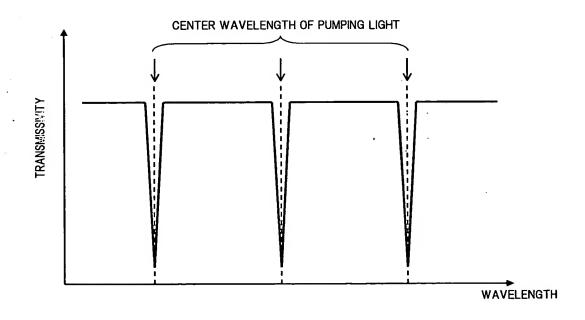


FIG.17



**FIG.18** 

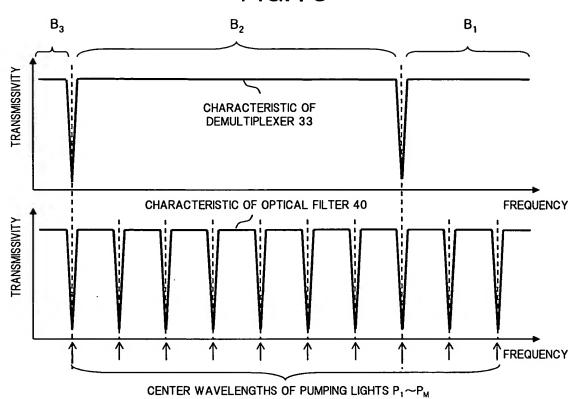
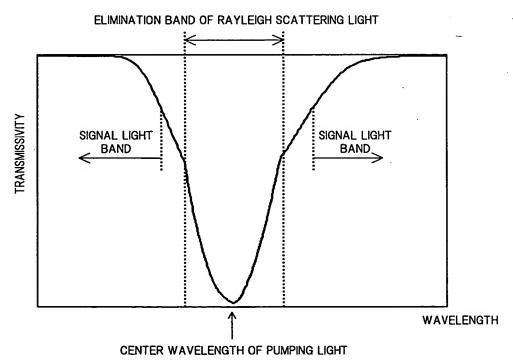


FIG.19



**FIG.20** 

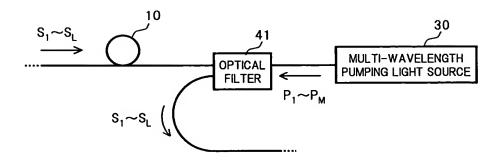
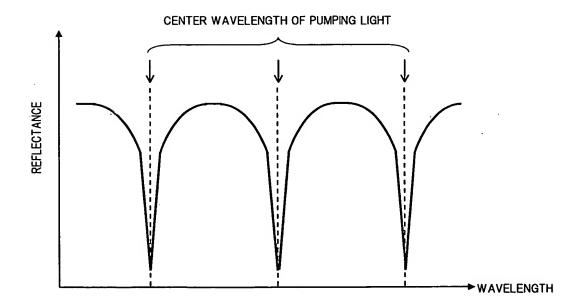


FIG. 21



E/0

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FIG.22

O/E

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RAMAN AMPLIFIERS OF PRESENT INVENTION ARE INCLUDED

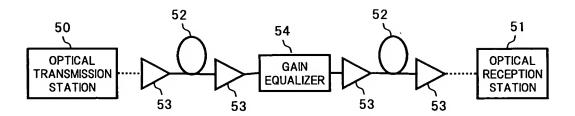
**20B** 

50A

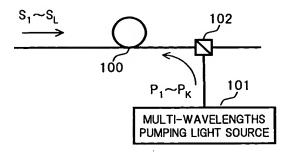
21

OPTICAL TRANSMISSION SYSTEM ACCORDING TO SIXTH EMBODIMENT OF PRESENT INVENTION

FIG.23

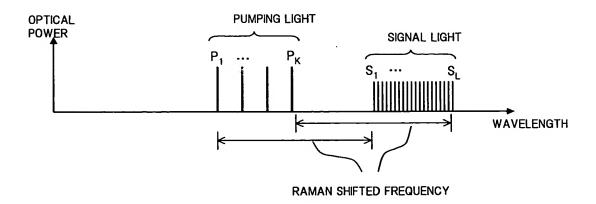


### CONFIGURATION EXAMPLE OF CONVENTIONAL RAMAN AMPLIFIER

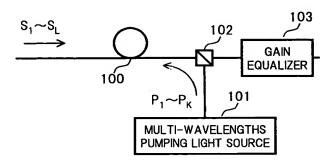


# **FIG.25**

### WAVELENGTH ALLOCATION EXAMPLE IN CONVENTIONAL RAMAN AMPLIFIER

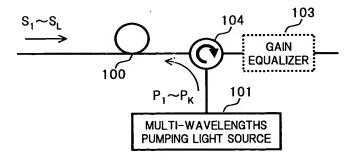


#### ANOTHER CONFIGURATION EXAMPLE OF CONVENTIONAL RAMAN AMPLIFIER



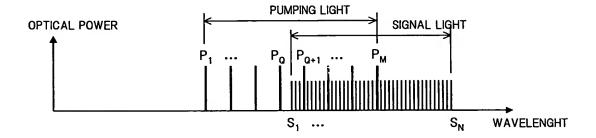
# **FIG.27**

#### ANOTHER CONFIGURATION EXAMPLE OF CONVENTIONAL RAMAN AMPLIFIER



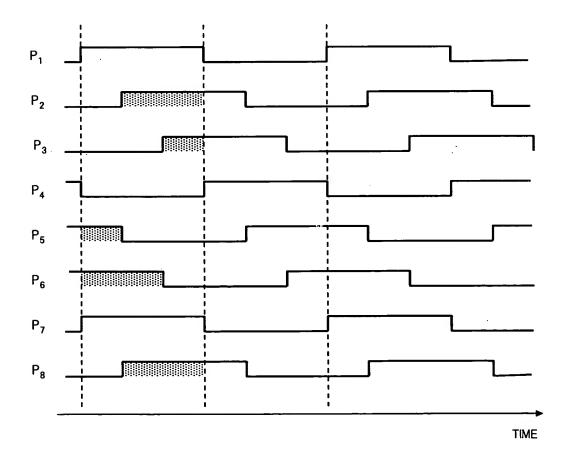
**FIG.28** 

### ANOTHER WAVELENGTH ALLOCATION EXAMPLE IN CONVENTIONAL RAMAN AMPLIFIER



**FIG.29** 

### EXAMPLE MODULATION SYSTEM FOR PUMPING LIGHT



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**FIG.30** 

### CHANGE IN PEAK WAVELENGTH OF TYPICAL RAMAN GAIN

WHEN PUMPING LIGHTS OF 1433nm AND 1464nm ARE USED

ONLY PUMPING LIGHT
OF 1464nm
OF 1433nm
OF 1433nm

OF 1433nm

OF 1433nm

OF 1433nm

OF 1433nm

OF 1433nm

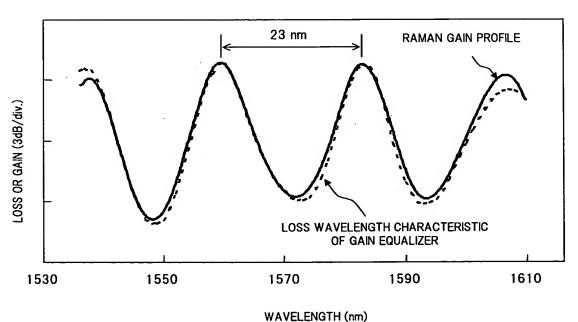
OF 1433nm

OF 1433nm

**FIG.31** 

WAVELENGTH (nm)

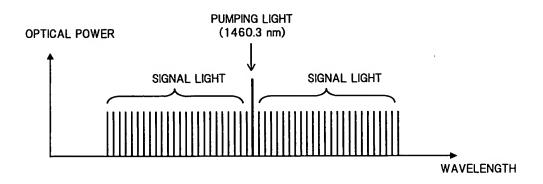
#### EXAMPLE OF CASE WHERE PUMPING LIGHT IS ARRANGED AT UNEQUAL INTERVAL



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FIG.32

EXAMPLE OF WAVELENGTH ALLOCATION IN WHICH SINGLE PUMPING LIGHT IS MIXED IN SIGNAL LIGHT BAND



**FIG.33** 

#### RAMAN EFFECT BY PUMPING LIGHT OF 1460.3 nm

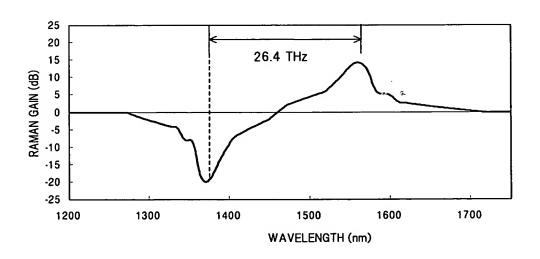
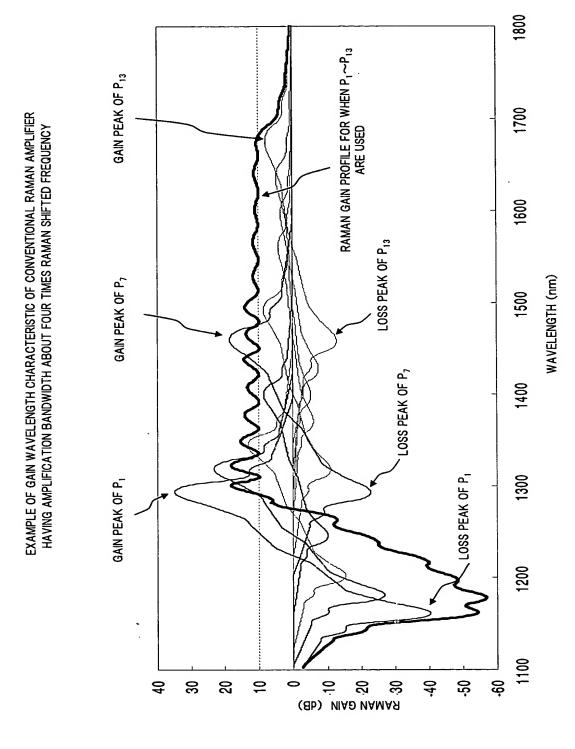


FIG.34



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FIG.35

EXAMPLE OF GAIN DEVIATION IN CONVENTIONAL RAMAN AMPLIFIER

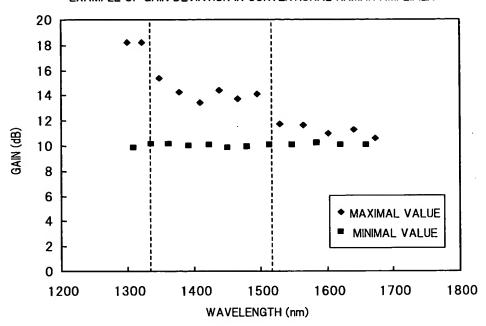
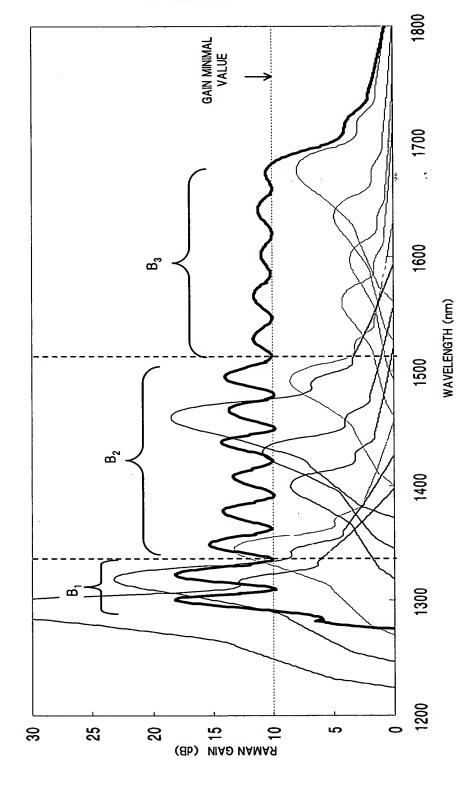
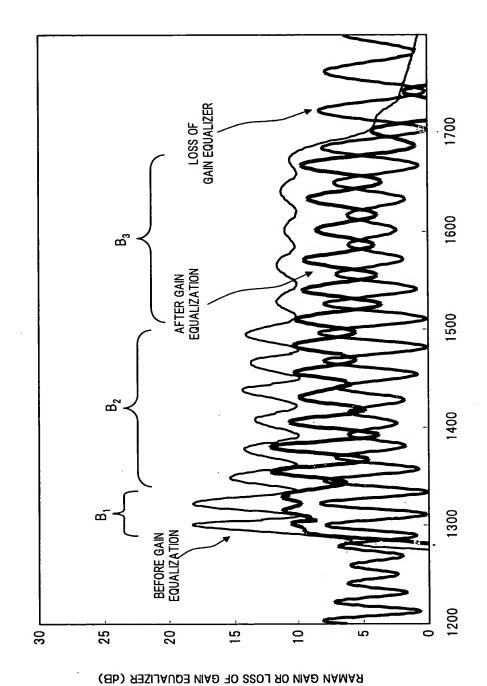


FIG.36



ENLARGED VIEW OF GAIN WAVELENGTH CHARACTERISTIC OF CONVENTIONAL RAMAN AMPLIFIER HAVING AMPLIFICATION BANDWIDTH ABOUT FOUR TIMES RAMAN SHIFTED FREQUENCY

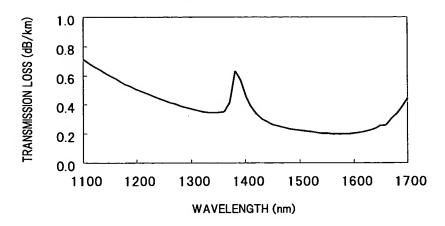
**FIG.37** 



EXAMPLE OF GAIN EQUALIZATION OF GAIN WAVELENGTH CHARACTERISTIC OF CONVENTIONAL RAMAN AMPLIFIER BY OPTICAL FILTER HAVING PERIODIC LOSS WAVELENGTH CHARACTERISTIC

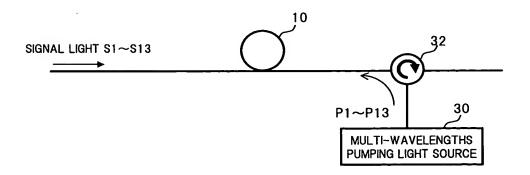
WAVELENGTH (nm)

# TRANSMISSION LOSS WAVELENGTH CHARACTERISTIC OF TYPICAL SINGLE-MODE OPTICAL FIBER



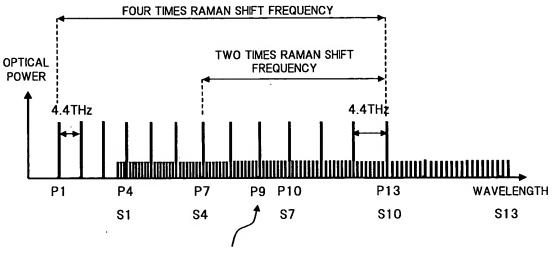
# **FIG.39**

### CONFIGURATION OF RAMAN AMPLIFIER IN SEVENTH AND EIGHTH EMBODIMENTS



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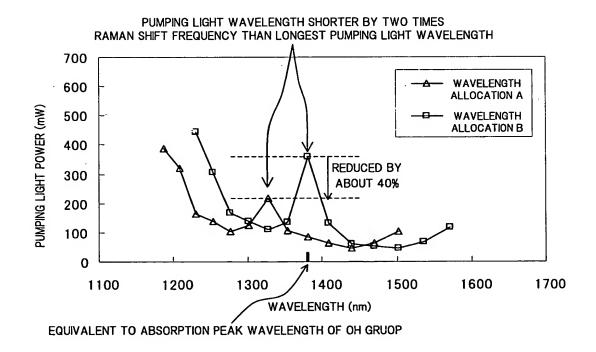
# WAVELENGTH ALLOCATION (WAVELENGTH ALLOCATION A) IN SEVENTH EMBODIMENT



ABSORPTION PEAK WAVELENGTH OF OH GROUP(ABOUT  $1.4\,\mu$  m)

**FIG.41** 

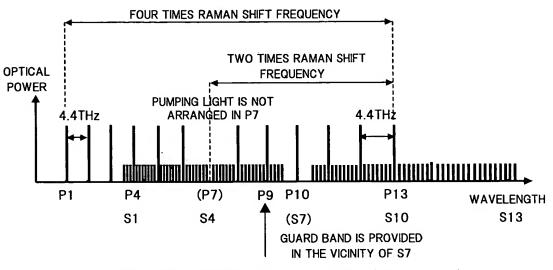
#### **EFFECT IN EMBODIMENT**



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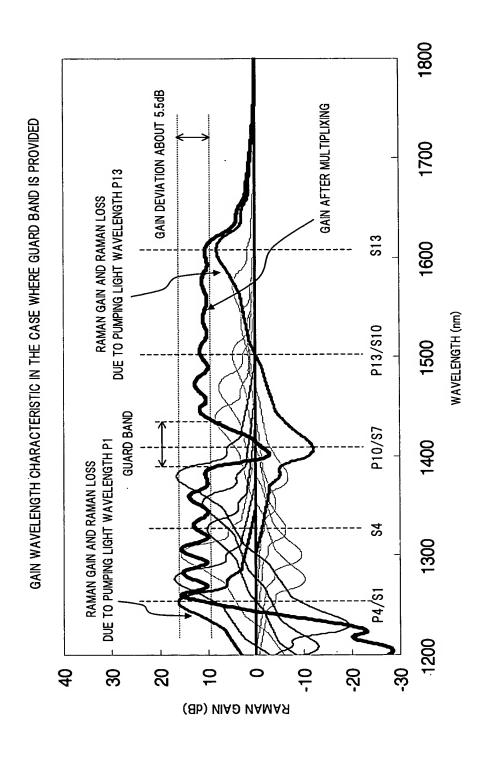
**FIG.42** 

# WAVELENGTH ALLOCATION IN THE CASE WHERE GUARD BAND IS PROVIDED (WAVELENGTH ALLOCATION C)



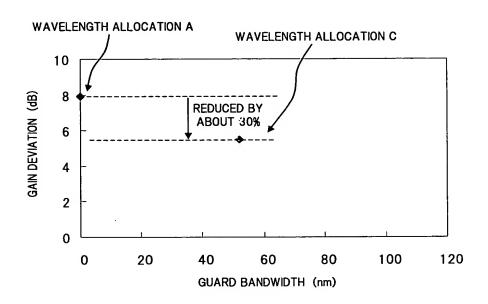
ABSORPTION PEAK WAVELENGTH OF OH GROUP (ABOUT 1.4  $\mu$  m)

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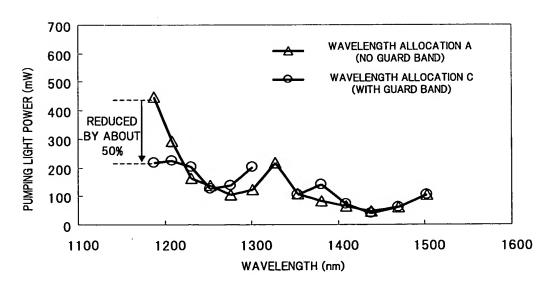
<sup>29/30</sup> FIG.44

### GAIN DEVIATION REDUCTION DUE TO PROVISION OF GUARD BAND



**FIG.45** 

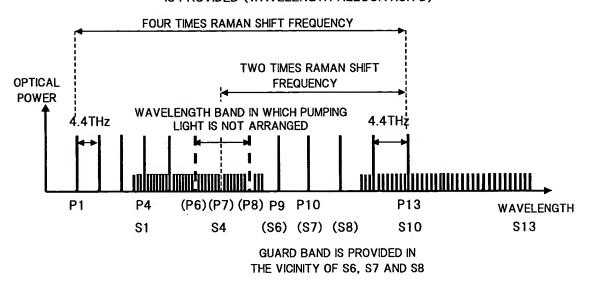
#### PUMPING LIGHT POWER IN THE CASE WHERE GUARD BAND IS PROVIDED



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**FIG.46** 

### WAVELENGTH ALLOCATION 2 IN THE CASE WHERE GUARD BAND IS PROVIDED (WAVELENGTH ALLOCATION D)



**FIG.47** 

#### GAIN DEVIATION REDUCTION 2 DUE TO PROVISION OF GUARD BAND

